Osteometric Examination of Metapodial Bones in Sheep (Ovis aries L.) and Goat (Capra hircus L.) Unearthed from the Yenikapı Metro and Marmaray Excavations in Istanbul^[1]

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Abstract

In this study, the metapodial bones of sheep and goats which were found out at Yenikapı Metro and Marmaray archaeological excavations in İstanbul were used. The variability of characteristic features of mentioned metapodia (CV values) were examined and calculations of shoulder heights were made with using metapodial evaluations. The results which were reached were compared with the data of modern and archaeological sheep and goats which belong to previous studies about this topic. Hereat, it is observed that the shoulder heights of Byzantine sheep are in same data range with Iron Age sheep and are in same size with one of the modern breeds Tuj sheep. It is confirmed that the shoulder heights of the Byzantine goats are higher than Iron Age goats and are in same size with one of the modern breeds Anatolian Black Goats.

Keywords: Metapodial bones, Yenikapı Metro and Marmaray, Sheep, Goat

İstanbul Yenikapı Metro ve Marmaray Kazılarında Ortaya Çıkan Koyun ve Keçi Metapodial Kemiklerinin Osteometrik İncelenmesi

Özet

Çalışmada, İstanbul Yenikapı Metro ve Marmaray bölgesi arkeolojik kazılarında ortaya çıkarılan koyun ve keçi metapodium'ları kullanıldı. Söz konusu metapodium'ların ana özelliklerinin değişkenlikleri (CV değerleri) incelendi ve metapodial ölçümler kullanılarak omuz yüksekliği hesaplamaları yapıldı. Elde edilen sonuçların bu konu üzerinde yapılmış çalışmalardaki modern ve arkeolojik koyun-keçi verileri ile karşılaştırılması yapıldı. Bunun sonucunda; Bizans dönemi koyunların omuz yüksekliğinin, Demirçağ koyunları ile aynı veri aralığında, modern ırklardan ise Tuj ırkı koyunlarının ebatında olduğu gözlendi. Bizans dönemi keçilerin omuz yüksekliği, Demirçağ keçilerinden daha yüksek, modern ırklardan ise Anadolu Kıl keçisi ebatlarında olduğu tespit edildi.

Anahtar sözcükler: Metapodial kemikler, Yenikapı Metro ve Marmaray, Koyun, Keçi

INTRODUCTION

Yenikapi Metro and Marmaray excavations has started with Marmaray sub-sea tunnel project in 2004 and is still going on. Excavation area is 58.000 m² wide and with many archaeological material, animal bones were also found ^[1]. The ongoing excavation confirmed that the region is ancient harbour of Theodosius ^[1-3]. Together

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with dating the archaeological material in the excavation area, animal bones were also radiocarbon dated and the mentioned skeletons belong to different ages between early (4-7th century) and late (15th century) Byzantine ^[4].

The excavation bones are not only giving information about only animal-human relations, but also the parameters such as visual morphological features, diseases of animal population and animal husbandry.

By examining the obtained ruins determination of many morphological parameters were provided (weight, shoulder height, age, sex, physical structure of animal) ^[5-10]. Information about visual morphology was obtained by using evaluation of metapodia specially ^[10,11]. For the enlightenment of history of domestication of sheep ^[10-12] and goats ^[10,13], metapodia were often used to determining morphological changes in this duration. In the studies, estimated shoulder heights were calculated by using evaluations of metapodia which obtained in archaeological excavations and classification of species was tried to be identified by comparing with archaeological data and actual breeds.

In this study, the metapodial slenderness index which classificates the individuals as "slender" or "thick" and playing a role for determining of visual features was used (SD/GL*100)^[5,14,15]. Distribution of CV was examined for the osteometric evaluation of aforementioned metapodiums and the data which were used in identification of breed were obtained by using these values^[11,16,17].

We believe that the metapodia data obtained will enlighten the definition of sheep and goat population of Byzantine age, socio-economic condition of region and ancient animal husbandry of Istanbul where is the heart of Byzatine.

MATERIAL and METHODS

In this study, the metapodial bones of adult sheep and goat, which were found in Yenikapı Metro and Marmaray excavations were used. For this purpose, sheep with maximum numbers of 148 metacarpus and 219 metatarsus bones were examined while maximum number of metapodial bones for goats were 65 and 92 respectively which were examined.

Measurements of metapodial bones were taken by digital calliper with precision of 0.01 mm. The measurements were made as described in Onar et al.^[10], Berteaux and Guintard^[14], Davis^[16], Guintard and Lallemand^[17], Daugnora^[18], Driesch^[19], Haak^[20], Rowley-Conwy's^[21] studies and taken from measuring points which stated below.

Morphometric measurements (Fig. 1)

GL: Greatest length Bp: Width of proximal end Dp: Depth of proximal end SD: Smallest width of diaphysis in the medio-lateral axis d: Mid-shaft width of diaphysis e: Mid-shaft depth of diaphysis in the dorso-palmar axis DD: Smallest depth of diaphysis in the dorso-palmar axis Bd: Width of distal end Be: Greatest width of metaphysis in the medio-lateral axis De: Greatest depth of metaphysis in the dorso-palmar axis Dd: Depth of distal end DIM: Antero-posterior diameter of the internal trochlea of the medial condyle DEM: Antero-posterior diameter of the external trochlea of the medial condyle DIL: Antero-posterior diameter of the internal trochlea of the lateral condyle DEL: Antero-posterior diameter of the external trochlea of the lateral condyle WCM: Medio-lateral width of the medial condyle WCL: Medio-lateral width of the lateral condyle

Calculation of mean values, SD values and CV values of above mentioned measurements were made for the two breeds. SPSS 8.0 and Excel programs were used for the calculation of statistical data. (SD/GL*100) metapodial slenderness index which was used for determining the

 Fig 1. Measurements taken from the metapodial bones (sheep-goat), A- Dorsal view of metacarpus; B- Lateral view of metacarpus; D- Proximal view of metatarsus; E- Distal view of metatarsus
 Image: C- Proximal view of metacarpus; D- Proximal view of metacarpus; D- Metacarpus'un point and görünüşü; B- Metacarpus'un lateral görünüşü; B- Metacarpus'un proksimal görünüşü; D- Metatarsus'un distal görünüşü
 Image: C- Proximal view of metacarpus view of metacarpus; D- Proximal view of metacarpus; D- Proximal view of metacarpus; D- Proximal view of metacarpus; D- Proximal view of metacarpus view of meta

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thinness of skeleton were calculated by using metapodial calculation of bones of both species ^[5,14,15].

Shoulder height estimation which provides to estimate the visual morphology, has been calculated by using metapodial values taken from sheep and goats ^[20,22]. Visual morphology was tried to be estimated by comparing the data of shoulder heights of the two species with current data of goat and sheep ^[23,24].

RESULTS

Mean values, SD values and mean of CV values of osteometric values of metapodial bones of sheep and goats which were obtained from excavation for this study was given in *Table 1* and *Table 2*. Due to some of the metapodial bones have only distal or proximal fragments, material numbers which were used for each evaluation was subject to vary.

According to osteometrical evaluation results of sheep metacarpi, it was determined that the minimum variability was in Dp measurement (CV: 8.40%) while the maximum variability was observed in DD measurements (CV: 12.03%). When metatarsi were examined, it was determined that maximum variability was in DD (CV: 8.49%) and minimum variability was in Bd (CV: 5.91%) (*Table 1*).

In the measurements of metapodium of goats for metacarpus, it was found that maximum variability was in Bd measurement (12.32%) and minimum variability was in WCM (7.24%) measurement. The maximum variability

condyle, WCL: Medio-lateral width of the lateral condyle

of goat metatarsi was in De measurements (%9.78) and minimum variability was observed in DIL measurements (6.79%) (*Table 2*).

Metapodial slenderness index was calculated for metacarpi and metatarsi of both species seperately. While metapodial slenderness index for metacarpi of sheep was observed 11.70 \pm 1.12, index of metatarsi was determined 9.45 \pm 0.73 (*Table 3*). Aforementioned index values for metacarpi and metatarsi were calculated 14.89 \pm 1.24 and 11.11 \pm 0.79 for goats respectively.

In this study, estimated shoulder heights of sheep and goats were calculated by using metacarpi and metatarsi which were obtained. Thus shoulder heights data were acquired for both species (*Table 3, Table 4*). Mean value for the shoulder height of sheep was estimated as 60.79 cm while it was determined as 65.55 cm for goats. It was found that the value of CV (7.89%) lower in shoulder height results which were calculated with the values of metatarsi of sheep was lower. For goats, unlike the sheep CV value (8.18%) of estimated shoulder height was the lowest which were determined by using results of metacarpus measurements.

DISCUSSION

In this study, osteometric measurements were made on metapodial bones of sheep and goats which were found in İstanbul Yenikapı Metro and Marmaray excavations. The variabilities of main features of metapodia were researched and these features were compared with the

Bone	Statistical								Mea	sureme	ents							
Bolle	Values	GL	Вр	Dp	SD	d	е	DD	Bd	Ве	De	Dd	DIM	DEM	DIL	DEL	WCM	wc
	N	136	147	147	148	148	148	148	136	145	145	135	135	137	135	136	135	134
	Mean	124.91	24.51	17.51	14.56	14.71	10.98	9.98	26.74	27.00	14.10	16.42	14.24	11.98	14.32	11.06	12.66	12.1
Metacarpus	SD	11.04	2.45	1.47	1.74	1.52	1.13	1.20	2.49	2.41	1.41	1.43	1.29	1.26	1.35	1.18	1.21	1.2
metacarpus	Min	105.85	20.36	14.74	10.79	10.82	8.70	7.83	22.63	22.38	11.61	13.10	11.73	9.26	11.68	8.70	10.72	10.2
	Max	180.31	47.31	28.03	25.73	25.64	19.09	18.49	48.85	45.12	24.04	25.15	23.86	21.82	24.99	20.40	23.27	22.5
	%CV	8.84	10.00	8.40	11.92	10.32	10.25	12.03	9.31	8.93	10.03	8.69	9.06	10.52	9.40	10.70	9.55	9.87
	N	203	219	217	219	219	219	217	208	216	216	207	209	210	207	208	207	207
	Mean	134.05	21.33	21.15	12.61	12.90	12.15	10.51	25.31	25.38	14.46	16.28	14.06	11.25	14.07	10.36	12.11	11.1
Metatarsus	SD	10.57	1.45	1.48	1.02	1.08	0.95	0.89	1.50	1.69	1.18	1.16	0.92	0.84	0.92	0.76	0.77	0.6
Metalarsus	Min	104.09	18.20	13.69	10.00	10.21	10.14	8.66	21.36	21.10	11.68	12.98	11.39	8.94	11.56	8.52	10.19	9.35
	Max	161.29	28.87	25.28	15.47	15.94	15.36	14.45	29.51	30.84	18.55	20.36	17.31	14.53	17.55	12.84	14.37	13.1
	%CV	7.89	6.78	6.98	8.05	8.33	7.86	8.49	5.91	6.64	8.20	7.10	6.57	7.47	6.57	7.38	6.33	6.05
GL: Greatest ler diaphysis, e: Mic width of metapl of the internal to	d-shaft depth o hysis in the mea	f diaphys lio-laterc medial co	is in the al axis, D ondyle, I	dorso-j)e: Grea DEM: Ai	palmar test dep ntero-po	axis, DE oth of me osterior): Smalle etaphys diamete	est depti is in the er of the	h of dia dorso-p e externa	physis ir palmar c al trochi	n the doi axis, Dd: lea of th	rso-palr Depth e medic	nar axis of distal al condy	, Bd: Wi end, Di (le, DIL:	dth of d M: Ante Antero-	istal en ro-post posterio	d, Be: Gi erior dic or diam	reate: amete eter o

Dama	Statistical								Mea	sureme	ents							
Bone	Values	GL	Вр	Dp	SD	d	e	DD	Bd	Be	De	Dd	DIM	DEM	DIL	DEL	WCM	WCI
	N	57	64	64	65	54	53	63	57	53	51	54	57	57	55	55	57	55
	Mean	115.52	26.04	17.81	17.30	17.95	11.42	11.31	28.66	28.77	14.54	17.19	14.75	11.07	14.85	10.51	13.44	13.0
	SD	9.44	2.15	1.47	1.80	1.85	1.09	1.19	3.53	3.08	1.40	1.33	1.40	0.89	1.40	0.82	0.97	1.08
Metacarpus	Min	99.57	21.77	14.82	13.34	14.05	9.56	9.36	15.86	18.64	11.69	14.12	12.00	9.66	12.10	8.76	11.59	10.9
	Max	142.92	30.51	21.15	22.10	22.92	15.88	15.03	35.50	34.15	17.14	19.70	19.79	13.33	19.49	12.55	15.48	15.7
	%CV	8.18	8.25	8.24	10.41	10.33	9.52	10.52	12.32	10.72	9.65	7.72	9.49	8.05	9.45	7.82	7.24	8.27
	N	78	90	88	92	76	76	87	75	69	69	76	77	77	77	78	76	75
	Mean	121.13	20.83	19.67	13.53	13.88	11.62	10.36	25.03	25.42	13.87	16.04	13.77	10.44	13.87	9.97	11.83	11.2
Matata	SD	11.40	1.53	1.70	1.23	1.27	1.13	0.93	1.88	2.12	1.36	1.29	0.95	0.83	0.94	0.71	0.91	0.92
Metatarsus	Min	97.78	17.73	15.92	9.06	9.26	8.63	8.10	21.90	20.32	11.66	13.28	12.01	9.07	11.73	8.53	10.44	9.85
	Max	165.19	24.24	24.48	16.39	16.87	14.61	12.55	28.94	29.71	16.63	19.17	16.59	13.15	16.21	11.50	14.10	14.8
	%CV	9.41	7.36	8.64	9.12	9.12	9.70	8.97	7.49	8.32	9.78	8.04	6.90	7.91	6.79	7.11	7.70	8.19

GL: Greatest length, *Bp*: Width of proximal end, *Dp*: Depth of proximal end, *SD*: Smallest width of diaphysis in the medio-lateral axis, *d*: Mid-shaft width of diaphysis, *e*: Mid-shaft depth of diaphysis in the dorso-palmar axis, *DD*: Smallest depth of diaphysis in the dorso-palmar axis, *Bd*: Width of distal end, *Be*: Greatest width of metaphysis in the medio-lateral axis, *DE*: Greatest depth of metaphysis in the dorso-palmar axis, *DD*: Smallest depth of metaphysis in the dorso-palmar axis, *Dd*: Depth of distal end, *Be*: Greatest width of metaphysis in the medio-lateral axis, *DE*: Greatest depth of metaphysis in the dorso-palmar axis, *Dd*: Depth of distal end, *DIM*: Antero-posterior diameter of the internal trochlea of the medial condyle, *DEM*: Antero-posterior diameter of the external trochlea of the lateral condyle, *DEL*: Antero-posterior diameter of the external trochlea of the lateral condyle, *DEL*: Antero-posterior diameter of the external trochlea of the lateral condyle, *DEL*: Antero-posterior diameter of the external trochlea of the lateral condyle, *WCM*: Medio-lateral width of the medial condyle

	Tablo 3. Koyunların metapodial incelik indeksi ve tahmini omuz yüksekliğinin hesaplanması									
Animal	Statistical	Meta	arpus	Meta	tarsus					
Animai	Values	MSI	SH (cm)	MSI	SH (cm)					
	N	136	136	203	203					
	Mean	11.70	60.58	9.45	60.99					
Chase	SD	1.12	5.36	0.73	4.81					
Sheep	Min	9.80	51.34	7.65	47.36					
	Max	19.66	87.45	11.80	73.39					
	%CV	9.56	8.84	7.77	7.89					

Table 3. Metapodial slenderness index of sheep and calculation of

estimated shoulder height

MSI: Metapodial Slenderness Index, SH: Estimated Shoulder Height

Table 4. Metapodial slenderness index of goats and calculation of estimated shoulder height

Tablo 4. Keçilerin metapodial incelik indeksi ve tahmini omuz yüksekliğinin hesaplanması

Animal	Statistical	Metao	arpus	Meta	arsus
Animal	Values	MSI	SH (cm)	MSI	SH cm)
	N	57	57	78	78
	Mean	14.89	66.42	11.11	64.68
Goat	SD	1.24	5.43	0.79	6.09
GOal	Min	11.73	57.25	8.79	52.21
	Max	17.06	82.18	12.75	88.21
	%CV	8.34	8.18	7.11	9.41
MSI: Metap	odial Slendernes	s Index, SH :	Estimated S	Shoulder He	ight

previous studies about modern and archaeological sheepgoat population.

CV values which were obtained from the measuring points of metapodia of sheep and goats were calculated (Table 5). While CV values of metacarpus measurements of sheep varies between 12.03% (DD) and 8.40% (Dp), these values were between 8.49% (DD) and 5.91% (Bd) for metatarsus. The aforementioned values varies between 12.32% (Bd) and 7.24% (WCM) for metacarpi relating to goats, where as 9.78% (De) and 6.79% (DIL) for metatarsi. Obtained CV values were found as higher than the maximum values which Haak [20] and Davis [16] and lower than the maximum values that Guintard and Lallemand [17] defined. Because there is not any sampling method for data in archaeological excavations, homogeneous distribution may not be expected. In this study, variation in CV values suggests the bone samples probably belong to different breeds and genders. The CV values are not high as much as in modern breed studies [11,17] so that it supports the obtained sampling may be close to homogeneous.

Guintard and Lallemand ^[17] noted in their studies that GL is the main measurement for the assesment of slenderness of bone. They used this parameter for categorizing breeds as "tall" for higher and "short" for lower than 135 mm. Considering the GL values of metacarpus and metatarsus of sheep and goats which we used in our study, these values vary between 115.52 mm and 134.05 mm and therefore individuals belong to both species must be categorized as "short".

Imatrial Lallermand 200 Marmaray Castle Lallermand 200 Marmaray Castle Female Lallermand 200 11.92 DD 7.34 SD d 15.04 d 11.92 DD 7.34 SD 11.5.04 d 11.5.04 d 10.70 SD 6.92 Bp 10.79 e 9.55 Bp 10.025 GL 6.38 e 9.55 Bp 10.79 e 10.03 Be 5.61 Dp 9.37 Dp 9.37 Dp 10.03 Be 5.61 Dp 8.42 DEL 8.42 DEL 9.61 Dp 5.21 WCM 8.42 DEL 8.44 DIM 9.65 Bd 7.79 DIL 7.79 DIL 7.79 DIL 7.79 DIL 8.69 8.49 DDM 7.73 GL 8.04 DIM 7.78 D </th <th>2002 Male d 19,61 SD 18,85 e 15,24 e 15,24 13,32 MCL 13,09 13,32 MCL 13,09 13,32 MCL 13,09 13,32 MCL 13,09 13,32 MCL 13,09 13,32 MCL 13,09 13,32 MCL 13,09 MM 11,75 M</th> <th>Guintard Guintard d 15 Bb Bb Bb Bc Bc Bc Bc Bc Bc Bc Bc Bc Bc DD DE Bc Bc Bc Bc DE Bc DC<</th> <th>Guintard and Lallemand 2003 Female Male Female Male a 15.04 d 19.6 SD 14.52 SD 14.33 Bp 9.56 Bp 13.70 e 9.55 Bp 13.37 e 9.55 Bp 13.33 e 9.55 Bp 13.33 e 9.55 Bp 13.33 DD 9.37 Dp 13.33 DD 8.42 Dp 13.33 DD 8.32 Dp 13.33 05 DD 8.42 Dp 13.36 05 DD 8.42 Dp 13.36 05 DEL 8.32 WCM 11.26 05 DEM 8.14 Bd 11.12 05 Dd 7.33 GL 11.12 05 DIL 7.36 De 11.22 05 DIM 7.36</th> <th>Aller and a second seco</th> <th>2003 e 19.61 19.61 18.85 15.24 14.32 13.32 13.30 11.3.6 11.3.6 11.3.6 11.3.6 11.3.6 11.5 11.5 11.5 11.5 11.5 11.5 11.5 8 11.5 8 11.5 12.6 11.5 12.6 13.6 13.7 11.5 12.6 13.6 13.5 13.5 13.5 13.5 13.5 13.5 13.5 13.5</th> <th>Davis 1996 Cvall) Cvall) (Cvall) 5.8 DEM 5.8 DEL 5.4 DIL 4.7 Bp 3.5 GL 3.6 WCM 3.6 WCL 3.6 WCL 3.6</th> <th>996 11 33,0 34,0 35,0</th> <th>Davis 1996 Covav+good) Female Female 5.8 DEL 5.4 SD Bp 3.9 GL Bp GL WCM WCL Bd WCL 3.6</th> <th></th> <th>Yenikapi Metro Bd 12.32 Be 10.72 Be 10.72 Br 10.52 SD 10.41 d 9.65 e 9.52 DIL 9.45 WCL 8.27 DD 8.25 DE 8.18 DEL 7.72 WCM 7.24</th> <th></th> <th>Upper Anzaf Castle GL 9.61 GL 9.23 e 8.09 Dp 7.46 DD 7.04 Bd 7.83 Bd 5.94 Bd 5.94 Bd 4.83</th>	2002 Male d 19,61 SD 18,85 e 15,24 e 15,24 13,32 MCL 13,09 13,32 MCL 13,09 13,32 MCL 13,09 13,32 MCL 13,09 13,32 MCL 13,09 13,32 MCL 13,09 13,32 MCL 13,09 MM 11,75 M	Guintard Guintard d 15 Bb Bb Bb Bc Bc Bc Bc Bc Bc Bc Bc Bc Bc DD DE Bc Bc Bc Bc DE Bc DC<	Guintard and Lallemand 2003 Female Male Female Male a 15.04 d 19.6 SD 14.52 SD 14.33 Bp 9.56 Bp 13.70 e 9.55 Bp 13.37 e 9.55 Bp 13.33 e 9.55 Bp 13.33 e 9.55 Bp 13.33 DD 9.37 Dp 13.33 DD 8.42 Dp 13.33 DD 8.32 Dp 13.33 05 DD 8.42 Dp 13.36 05 DD 8.42 Dp 13.36 05 DEL 8.32 WCM 11.26 05 DEM 8.14 Bd 11.12 05 Dd 7.33 GL 11.12 05 DIL 7.36 De 11.22 05 DIM 7.36	Aller and a second seco	2003 e 19.61 19.61 18.85 15.24 14.32 13.32 13.30 11.3.6 11.3.6 11.3.6 11.3.6 11.3.6 11.5 11.5 11.5 11.5 11.5 11.5 11.5 8 11.5 8 11.5 12.6 11.5 12.6 13.6 13.7 11.5 12.6 13.6 13.5 13.5 13.5 13.5 13.5 13.5 13.5 13.5	Davis 1996 Cvall) Cvall) (Cvall) 5.8 DEM 5.8 DEL 5.4 DIL 4.7 Bp 3.5 GL 3.6 WCM 3.6 WCL 3.6 WCL 3.6	996 11 33,0 34,0 35,0	Davis 1996 Covav+good) Female Female 5.8 DEL 5.4 SD Bp 3.9 GL Bp GL WCM WCL Bd WCL 3.6		Yenikapi Metro Bd 12.32 Be 10.72 Be 10.72 Br 10.52 SD 10.41 d 9.65 e 9.52 DIL 9.45 WCL 8.27 DD 8.25 DE 8.18 DEL 7.72 WCM 7.24		Upper Anzaf Castle GL 9.61 GL 9.23 e 8.09 Dp 7.46 DD 7.04 Bd 7.83 Bd 5.94 Bd 5.94 Bd 4.83
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DD 12.03 De 7.84 d 15.04 SD 11.92 DD 7.34 SD 1452 DEL 10.70 SD 6.92 BP 10.79 DEM 10.52 e 6.73 SD 1452 DEM 10.52 e 6.73 SD 1452 DEM 10.52 e 6.74 GL 9.56 DP 10.03 BP 5.64 Be 9.07 DP 10.03 BP 5.61 DP 9.37 WCL 9.87 DP 5.51 WCM 8.42 VCM 9.55 Bd 4.13 DEL 8.32 WCM 9.55 Bd 4.13 DE 8.32 DIL 9.31 9.06 7.79 8.44 7.79 DD 8.84 DD 8.44 7.78 8.44 DD 8.849 DD 7.79 8.44 7.79		d B B B B B C M C M C M C M C M D C M C M D C M C M	15.04 14.52 9.56 9.55 9.37 9.07 8.42 8.32 8.32 8.32 8.14 8.14 8.14 8.14 8.14 8.14 7.97 7.73 7.73 7.73	d e B D D B B B B C C C D C C C C D C C C C	19.61 18.85 15.24 14.32 13.76 13.30 13.30 11.298 11.269 11.269 11.269 11.269 11.75 11.75 11.75 11.75 11.75 11.74 11.75 1	DEM DEF DIL DIL BB WCC WCC	5, 75 7, 7, 4, 4, 5 8, 5, 6, 8, 8, 9, 7, 6, 8, 9, 9, 9, 9, 9, 9, 9, 9, 9, 9, 9, 9, 9,	DEM DEL SD DIN Bb GL WCM WCL Bd	3.6 3.6 3.6 3.6 3.6 3.6 3.6 3.6 3.6 3.6			
SD 11.92 DD 7.34 SD 14.52 DEL 10.70 SD 6.73 Bp 10.79 DE 10.72 e 6.74 GL 9.56 d 10.32 E 6.38 Bp 10.79 d 10.32 GL 6.36 DD 9.56 d 10.33 Be 5.61 DP 9.37 Bp 10.00 Bp 5.61 DP 8.42 WCL 9.87 DP 5.21 WCM 8.42 WCL 9.97 DP 5.21 WCM 8.42 WCL 9.93 Bd 4.13 DEL 8.32 DIL 9.40 S.21 WCM 8.42 Bd 9.31 DEM 8.14 2.79 DIL 9.40 S.21 WCL 8.32 Bd 9.31 DEM 8.14 2.79 DI 8.83 S.01 DI 7.79 DD 8.83 S.01 DI 7.73 </th <th></th> <th>S C B B B C B C D C D C D C D C D C D C D C D C D C D</th> <th>7.18 10.79 10.79 9.35 9.37 9.07 8.42 8.42 8.42 8.14 8.14 8.14 8.14 7.97 7.73 7.73 7.73 7.73</th> <th>e e e e B B B B B B B B B B B B C C F B B C C C D C E M C D C D C D D D D D D D D D D D D D D</th> <th>18.85 15.24 15.24 13.76 13.32 13.32 13.32 13.32 11.26 11.26 11.26 11.26 11.75 11.75 11.75 11.74 11.75 11.74 11.74 11.75 11.75</th> <th>BP WCL Bd Br</th> <th>5 5 5 4 2 5 5 4 4 7 5 5 4 4 7 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9</th> <th>DEL DIN BP GL WCM WCL Bd</th> <th>3.5 3.6 3.6 3.6 3.6 3.6 3.6 3.6 3.6 3.6 3.6</th> <th></th> <th></th> <th></th>		S C B B B C B C D C D C D C D C D C D C D C D C D C D	7.18 10.79 10.79 9.35 9.37 9.07 8.42 8.42 8.42 8.14 8.14 8.14 8.14 7.97 7.73 7.73 7.73 7.73	e e e e B B B B B B B B B B B B C C F B B C C C D C E M C D C D C D D D D D D D D D D D D D D	18.85 15.24 15.24 13.76 13.32 13.32 13.32 13.32 11.26 11.26 11.26 11.26 11.75 11.75 11.75 11.74 11.75 11.74 11.74 11.75 11.75	BP WCL Bd Br	5 5 5 4 2 5 5 4 4 7 5 5 4 4 7 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	DEL DIN BP GL WCM WCL Bd	3.5 3.6 3.6 3.6 3.6 3.6 3.6 3.6 3.6 3.6 3.6			
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DEM 10.52 e 6.74 GL 9.56 d 10.32 Dd 6.38 e 9.55 d 10.32 GL 6.36 DD 9.37 De 10.03 Be 5.64 Be 9.07 Bp 10.00 Bp 5.61 Dp 8.37 WCL 9.87 Dp 5.21 WCM 8.42 WCL 9.55 Bd 4.13 DEL 8.32 DIL 9.40 5.21 WCM 8.42 9.07 Bd 9.31 Dp 5.21 WCM 8.42 DIL 9.40 Dp 5.21 WCM 8.42 Bd 9.31 Dp 5.21 WCM 8.42 DIL 9.40 N N N 8.42 Bd 8.33 De 8.31 7.79 Dd 8.33 Dd 7.73 8.04 Dd 8.3		e GL e DD DE DE DE DI DI DI	9,56 9,55 9,37 9,07 8,56 8,32 8,32 8,14 8,14 8,14 8,14 7,97 7,73 7,73 7,73 7,73	DD Bp WCL DEM Bd DIL DIL DI C C C	14.32 13.76 13.32 13.09 12.08 12.09 11.26 11.75 11.75 11.75 11.74 11.75 11.74 11.74 11.74 11.24 9.97	DIL Bp WCC Bd Bd	4,9 3,0 3,0 3,0 3,0 3,0 3,0 3,0 3,0 3,0 3,0	DIL DIM BP WCM WCL Bd	4.9 4.7 3.6 3.6 3.6 3.6			
d 10.32 Dd 6.38 e 9.55 e 10.25 GL 6.36 DD 9.37 De 10.03 Be 5.61 DP 9.37 Bp 10.00 Bp 5.61 Dp 8.56 WCL 9.87 Dp 5.21 WCM 8.42 WCL 9.55 Bd 4.13 DEL 8.32 DIL 9.40 5.21 WCM 8.42 8.14 WCM 9.55 Bd 4.13 DEL 8.33 DIL 9.40 NCL 8.42 8.42 8.43 DIM 9.06 WCL 8.04 8.14 7.79 Be 8.93 Bd 7.79 Bd 7.79 Dd 8.33 DD MCL 8.04 7.79 Dd 8.33 SD Bd 7.79 8.04 Dd 8.33 SD Dd 7.73 8.04		e DD DE DE DE DI DI DI DI	9.55 9.37 9.07 8.56 8.32 8.32 8.14 8.14 8.14 7.97 7.73 7.73 7.73 7.73	Bp Dp WCL Be Bd DIK DIL DI C GL DI DI	13.76 13.32 13.09 12.98 12.69 11.26 11.26 11.75 11.75 11.75 11.74 11.75 11.74 11.24 9.97	Bp WCL WCL	4.7 3.6 3.6 3.6 3.6	DIM Bp GL WCM WCL Bd	3.9 3.6 3.6 3.6			
e 10.25 GL 6.36 DD 9.37 De 10.03 Be 5.61 Dp 9.37 Bp 10.00 Bp 5.61 Dp 8.56 WCL 9.87 Dp 5.21 WCM 8.42 WCL 9.55 Bd 4.13 DEL 8.32 DIL 9.40 5.21 WCM 8.42 WCM 9.55 Bd 4.13 DEL 8.32 DIL 9.40 5.21 WCM 8.42 8.42 DIL 9.40 5.21 WCM 8.42 8.43 DIL 9.40 NCL 8.42 8.42 8.42 DIM 9.06 WCL 8.04 7.79 8.42 DD 8.83 SD 8.64 7.79 8.04 DD 8.84 DD 7.79 8.04 7.79 DD 8.83 SD B 7.79 8.04 <		DD Be WCM DE DE DE Bd DIL	9.37 9.07 8.56 8.32 8.32 8.14 8.14 8.14 7.97 7.73 7.73 7.73 7.73	DP WCL Be Bd DIM DIM GL GL DI	13.32 13.09 12.98 12.59 11.26 11.26 11.75 11.75 11.74 11.74 11.74 11.24 9.97	Bp WCL WCL	3. 3. 9 3. 9 9. 9 9. 9 9. 9 9. 9 9. 9 9.	Bp GL WCM Bd	3.3.3 3.6 3.6			
De 10.03 Be 5.64 Be 9.07 Bp 10.00 Bp 5.61 Dp 8.56 WCL 9.87 Dp 5.21 WCM 8.42 WCL 9.55 Bd 4.13 DEL 8.32 WCM 9.55 Bd 4.13 DEL 8.32 DIL 9.40 5.21 WCM 8.42 WCM 9.55 Bd 4.13 DEL 8.32 DIL 9.40 P.0 5.21 WCM 8.42 Bd 9.31 DEM 8.14 7.79 Bd 8.93 Bd 7.79 Bd 7.79 DD 8.84 DD WCL 8.04 7.79 DD 8.49 DD 9.36 DIL 7.79 DD 8.49 DD 9.36 DIL 7.79 DD 8.33 SD 8.32 SD 12.66 B		Be Dp DEL DER WCL WCL DIE DIL	9.07 8.56 8.42 8.32 8.32 8.14 8.14 8.14 7.97 7.97 7.97 7.73 7.73 7.18	WCL Be WCM DEM DIM DIL DIL De Dd	13.09 12.98 12.72 12.69 112.69 11.26 11.74 11.74 11.58 11.24 9.97	GL WCM Bd	3.8 3.6 3.6	GL WCM Bd	3.8 3.6 6			
Bp 10.00 Bp 5.61 Dp 8.56 WCL 9.87 Dp 5.21 WCM 8.42 WCM 9.55 Bd 4.13 DEL 8.32 DIL 9.40 5.21 WCM 8.42 Bd 9.31 DE 8.21 8.32 DIL 9.40 5.21 WCM 8.42 Bd 9.31 DE 8.31 9.31 DIN 9.06 8.93 Bd 7.79 Be 8.93 Bd 7.79 Bd 7.79 DDM 9.06 NCL 8.04 7.79 Bd 7.79 DD 8.69 DM 9.36 DM 7.78 Bd 7.79 DD 8.49 DD 9.36 DI 7.79 101 7.18 DD 8.49 DD 9.36 DI 7.79 102.66 11.49 10.2 SD 8.03 SD		Dp WCM DEM WCL Bd DIL	8.56 8.42 8.32 8.21 8.14 8.04 7.97 7.73 7.73 7.73 7.73	Be DEL DEM DIM GL DIL DIL DIC	12.98 12.72 12.69 11.96 11.74 11.74 11.58 11.58	MCM WCL	3.6 3.6	WCM WCL Bd	3.6 3.6			
WCL 9.87 Dp 5.21 WCM 8.42 WCM 9.55 Bd 4.13 DEL 8.32 DIL 9.40 9.55 Bd 4.13 DEL 8.32 DIL 9.40 9.55 Bd 4.13 DEL 8.32 Bd 9.31 DIM 9.06 8.14 8.14 8.14 DIM 9.06 8.93 Bd 7.79 8.04 8.14 DIM 9.06 8.893 Bd 7.79 8.04 7.79 Dd 8.69 B 8.49 DD 9.36 d 7.36 DD 8.49 DD 9.36 d 13.73 6 11.49 DD 8.49 DD 9.36 d 13.73 6 11.49 Cl 7.89 DD 9.36 d 13.73 6 11.49 SD 8.03 SD 8.32 SD 12.66 11.49 </td <td></td> <td>WCM DEL DEM WCL WCL DIA DIL</td> <td>8.42 8.32 8.21 8.14 8.04 7.97 7.73 7.73 7.36 7.18</td> <td>DEL WCM DIM GL DI DI Ce</td> <td>12.72 12.69 12.32 11.96 11.75 11.74 11.58 11.24 9.97</td> <td>Bd KCL</td> <td>м . Ю</td> <td>MCL Bd</td> <td>3.6 w</td> <td></td> <td></td> <td></td>		WCM DEL DEM WCL WCL DIA DIL	8.42 8.32 8.21 8.14 8.04 7.97 7.73 7.73 7.36 7.18	DEL WCM DIM GL DI DI Ce	12.72 12.69 12.32 11.96 11.75 11.74 11.58 11.24 9.97	Bd KCL	м . Ю	MCL Bd	3.6 w			
9.55 Bd 4.13 DEL 8.32 9.40 9.31 DE 8.21 9.31 9.06 8.21 DE 8.21 9.05 Bd 7.79 Bd 7.79 8.69 Bd 7.73 Bd 7.73 8.69 Bd 7.73 Bd 7.73 8.40 DD Dd 7.73 8.49 DD 9.36 d 13.73 8.49 DD 9.36 d 13.73 8.33 SD 8.32 SD 13.73 8.30 D 9.36 d 13.73 8.30 E 8.32 SD 10.41 7.86 DF 7.86 DF 10.2 7.47 Be 7.26 DD 10.18 7.47 Be 7.26 DD 10.18		DEL DEM WCL Bd DIL	8.32 8.21 8.14 8.04 7.97 7.73 7.36 7.18	WCM DEM DIM GL De De	12.69 11.96 11.75 11.74 11.58 11.58 11.24 9.97	B	m	Bd	m			
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9.06 WCL 8.04 8.93 8.4 WCL 8.04 8.69 8.69 Bd 7.79 8.69 8.40 Dd 7.73 8.69 DD 9.36 d 13.73 8.33 SD 8.32 SD 12.66 8.33 SD 8.32 SD 11.49 8.05 Dp 8.04 GL 10.41 7.86 GL 7.71 DEL 10.2 7.86 GL 7.71 DEL 10.2 7.86 GL 7.71 DEL 10.2		WCL Bd DlL	8.04 7.97 7.73 7.36 7.18	DIM DIL De Dd	11.75 11.74 11.58 11.24 9.97						18 05 72 72	
8.93 8.93 84 7.79 8.84 Dd 7.73 8.69 B.40 7.73 8.49 DD 9.36 d 7.18 8.49 DD 9.36 d 13.73 8.33 SD 9.36 d 13.73 8.33 SD 9.36 d 13.73 8.33 SD 8.32 SD 12.66 8.05 DP 8.04 GL 10.41 7.86 GL 7.71 DEL 10.2 7.47 Be 7.26 DD 10.18		Bd DIL	7.97 7.73 7.36 7.18	DIL De Dd	11.74 11.58 11.24 9.97						.05 .82 .72 .24	
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8.33 SD 8.32 SD 12.66 8.33 SD 8.32 SD 12.66 8.05 Dp 8.04 GL 10.41 7.86 GL 7.71 DEL 10.2 7.47 Be 7.26 DD 10.18	1854	τ	13 73	τ	18 5.4	Ç	ر 1	G	4 5	0 U	0 78 O	11 14
8.20 e 8.29 e 11.49 l 8.05 Dp 8.04 GL 10.41 7.89 De 7.86 DEM 10.2 7.47 Be 7.26 DD 10.18		SD SD	12.66	SD	17.68	DIL	4.9	DIL	6.1			
8.05 Dp 8.04 GL 10.41 7.89 De 7.86 DEM 10.2 7.47 Be 7.26 DD 10.18		e	11.49	DEM	16.83	DIM	4.4	GL	3.7			
7.89 De 7.86 DEM 10.2 7.86 GL 7.71 DEL 10.2 7.47 Be 7.26 DD 10.18	e 16.64	GL	10.41	e	16.64	GL	4.1	DIM	3.5		9.12 D	p 8.67
7.47 Be 7.26 DD 10.18	DEL 16.3	DEL	10.20	DEL	16.30	Bd	3.2	Bd	2.9		9.12 De	
7.47 Be 7.26 DD 10.18		DEM	10.20	DD	16.14						8.97 Bp	
	Bp 15.3	DD	10.18	Bp	15.3					Dp 8		
DEL 7.38 BP 5.95 DP 10.04 DP	Dp 15.16	Dp	10.04	Dp	15.16						8.32 Dd	d 7.14
Dd 5.81 WCM 9.99		WCM	9.90	DIL	14.82						8.19 Be	
6.98 Bd 5.45 WCL 9.96	GL 14.55	WCL	9.96	GL	14.55					Dd 8	8.04 Bd	
Bp 6.78 Bp 9.95 WCL	VCL 14.47	Bp	9.95	WCL	14.47						7.91	
6.64 Be 9.52	0IM 14.45	Be	9.52	DIM	14.45						7.70	
DIL 6.57 Dd 9.44 De	De 14.39	Dd	9.44	De	14.39						7.49	
	Be 14.23	De	9.17	Be	14.23					Bp 7	7.36	
WCM 6.33 Bd 8.95 WCM	'CM 14.23	Bd	8.95	WCM	14.23						7.11	
WCL 6.05 DIL 8.5 Bd	Bd 13.71	DIL	8.50	Bd	13.71						6.90	
Bd 5.91 DIM 8.25 Dd	12.91 DC	DIM	8.25	Dd	12.91					DIL 6	02.2	

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Table 6. Comparison of the estimated shoulder heights of sheep and goats unearthed at the Yenikapı Metro and Marmaray excavations with the current breeds and archeological values

karşılaştırılması	Tablo 6. Yenikapı Metro ve Marmaray kazılarından elde edilen koyun ve keçilerin tahmini omuz yüksekliğinin günümüz ırklar ve arkeolojik verilerle
	karşılaştırılması

		Morphological Appearance a	nd Pattern	
Breeds	Shoulder Height (cm)	Distribution	Phenotypic Description	Size
Yenikapı Metro ve Marmaray Sheep	60.79			
Upper Anzaf Castle Sheep	59.93			
White Karaman ¹	Male: 62-67; Female: 63-66	Eastern/Central Anatolia	Fat-tailed	Medium-size
Red Karaman ¹	Male: 65-71; Female: 66-68	Eastern/Central Anatolia	Fat-tailed	Medium-size
Awassi ¹	Male: 70-80; Female: 60-70	Eastern/Central Anatolia	Fat-tailed	Medium-size
Karakul ²	65	Eastern/Central Anatolia	Fat-tailed	Medium-size
Tuj ²	60	Eastern Anatolia	Fat-tailed	Medium-size
Dağlıç²	58	Central-west Anatolia	Fat-tailed	Small
Yenikapı Metro ve Marmaray Goat	65.55			
Upper Anzaf Castle Goat	56.97			
Angora Goat ¹	Male: 55-60; Female: 50-55	Central Anatolia		
Anatolian Black Goat ¹	Male: 65-70; Female: 65-73	All region in Turkey		
Kilis Goat ¹	Male: 65-75; Female: 60-70	South-Eastern Anatolia		
¹ Soysal et al. ^[23] , ² Yalcin ^[24]	·			

Comparing with the literature that categorize the individuals as "heavy" and "light" according to metacarpus Bp values higher and lower than 27 mm, the values of individuals which belong to our study were evaluated lower than 27 mm thus small ruminants from Byzantine age defined as "light". The results of GL and Bp of sheep and goats in the zooarchaeological study of Onar et al.^[10] are same with our results and show that same breeds of that age are also "short" and "light". The metapodial bones were also used in osteological researches on development of sheep in South England during post medieval period ^[12]. According to the results of metapodial data, authors indicated that the sheep of that region were "light" and "short".

The morphological image of the sheep breeds in that study have parallelism with the ones in our study. Metapodial slender index was used in this study (SD/GL*100) which classified the individuals as "slender" and "thick" and effective for the evaluation of visual morphology ^[5,14,15]. While slenderness index varies between 9.45 and 11.70 for sheep, it was determined between 11.11 and 14.89 for goats. It is determined that results showed similarities with the results of animal bones which Onar et al.^[10] stated as "short" and "slender" breeds and obtained from Upper Anzaf Castle excavations.

The comparison of modern and archaeological sheep goat data is given particularly in this study which shoulder heights of both species are evaluated (*Table 6*)^[10,23,24]. The

size of the sheep of Byzantine age appear to be similar according to modern Tuj sheep breeded in Eastern Anatolia and archaeological Iron Age sheep. However the goats are 10 cm higher than archaeological Iron Age goats and in the same data range with modern breed "Anatolian Black Goat". It is known that gender and breeding regions are importantly effective on the size of goats ^[13].

Considering the examined metapodium numbers, breeding and consumption of sheep are higher compared to goats, same as Upper Anzaf Castle excavation studies. Metapodial values obtained which enables to determine the position of the population of sheep and goat and the visual morphological structure of this population, are of nature to enlighten the history of livestock in Istanbul which is the heart of Byzantine.

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